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ANIMAL INFESTIONS IN DISTRIBUTION SYSTEMS

William Marcus Ingram, et al

Robert A. Taft Sanitary Engineering Center
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ANIMAL INFESTATIONS IN DISTRIBUTION SYSTEMS

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INTRODUCTION

Published records describing animal infestations in distribution systems in the United States are meager (Ingram and Bartsch, 1960, 1960a). The modern water treatment plant with coagulation, sedimentation, rapid sand filtration, disinfection, and subsequent storage in covered clear wells and distribution reservoirs has done much to minimize household infestations. Finished water stored in uncovered distribution reservoirs, however, may mitigate the elaborate steps in purification at the water treatment plant. Treated water can be degraded by dirt, lawn fertilizers, leaves, or other organic contaminants entering the open reservoir. Such materials increase fertility and initiate organism food chains similar to ones that may develop in raw water

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(Plate I). Thus, immature and adult animals, as well as algal cells, pose potential, if not always actual, infestations to the consumer. Water supply systems lacking filtration prior to storage in open-water reservoirs foster maximal nuisances to plague the householder (Plate II).

Animals that have been reported in distribution systems and of special interest to the water works operator, and in certain instances to the consumer, are nematodes (roundworms), mollusks (snails and clams) (Plate III, Figs. 1-3), midge larvae (bloodworms), and crustacea (copepods and water fleas) (Plate IV, Figs. 1-3). Other animals causing occasional nuisances in distribution systems are: protozoa, sponges, rotifers, bryozoans, segmented worms, and aquatic sow bugs (water lice), to name some examples.* A manual discussing these and other animals, written solely for water works operators, has recently been issued by the American Water Works Association (Ingram and Bartsch, 1960). This manual has stimulated many to examine microscopically water from various basins in the water treatment plant, as well as finished water in the distribution system.

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* W. J. Downer's invitation to participate at this Fifth Sanitary Engineering Conference indicated that particular emphasis should be placed on "...snails, nematodes, and bloodworms." This has been done.

NEMATODE WORMS

Among animals that have been reported in distribution systems, nematode worms (Plate III, Fig. 1) are currently of great interest. A series of papers on roundworms in potable supplies has stimulated water works personnel to obtain precise information on occurrence of nematodes in finished water (Chang et al., 1959, 1960, 1960a; Chang, 1960, 1961). Chang et al. (1959) first reported a single species of nematode, Diplogaster nudicapitatus, taken from the distribution system of a city* water supply which used the Ohio River as the raw water source. Examination of tap water revealed worms at densities ranging from 1 to 20 per gallon; on one occasion as many as 100 worms were found in a gallon of water. Chang et al. (1960) in a survey of twenty-two water supplies reported that sixteen contained live, free-living nematodes; he records these additional genera: Rhabditis, Cheilobus, Monhystera, Aphelenchus, Cephalobus, Dorylaimus, and Turbatrix. He states:

> "While these nematodes are harmless per se when ingested, those of the Rhabiditidae family may possibly serve as carriers of human enteric pathogens. This is based on the facts that members of this family are frequently present in large numbers in trickling filters of municipal sewage treatment plants (unpublished observations of S.L.C.)** and that they feed readily on Proteus mirabilis, Aerobacter aerogenes, Ae. clocae and Pseudomonas sp. in laboratory cultures."

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* The name of the city was withheld by request (Chang et al., 1959).

** Chang, S. L. Cultivation and Life Cycle of Rhabditis limicola, Diplogaster nudicapitatus, and Cheilobus quadrilabiatus. To be published, as indicated in Chang et al., 1960.

Chang et al. (1960) reports on the experimental laboratory control of two worms, Cheilobus quadrilabiatus and D. nudicapitatus, by chlorine application; he states:

> "These nematodes are so highly resistant to the destructive action of free chlorine in water that they were not affected by 2.5-3.0 ppm of chlorine in a 120-minute exposure or by 15 to 45 ppm of chlorine in a 1-minute exposure when the water temperature was 25° C, pH 6.6-7.2, and the chlorine residuals were only slightly lower than initials. Even with an initial chlorine as high as 95-100 ppm, 50-60% of these nematodes survived a 5-minute contact and 10-20% survived a 15-minute contact. The C. quadrilabiatus appeared to be somewhat more resistant than the D. nudicapitatus, but the difference was reduced as the chlorine dosage was increased from 15 to 95-100 ppm."

Chang (1961) discusses possible control measures on a plant-scale basis, stating:

> "At present it appears that the most practical method for preventing nematode infestation is to prechlorinate the raw water for 6 hr; a free residual of 0.4-0.5 ppm chlorine should result at the end of this period. Although many of the nematodes are not killed, they are sufficiently affected so that they can no longer swim; therefore, they will be settled out in the flocculation process. The pH, in the range of 6.0-8.2, appears to have no detectable influence on the vermicidal activity of the free chlorine."

McCall's (1961) studies indicate that nematode worms, although not numerous, did occur in the Merrimack River, a raw water source of the Lawrence, Massachusetts, water treatment plant. Examination of finished water did not reveal worms to be present. The finished water had had the following treatment: rough and fine screening, prechlorination, coagulation with alum, mixing, settling, rapid sand filtration, pH control with lime, aeration, and postchlorination.

Fortunately, from an aesthetic point of view, the roundworms discussed above are microscopic (100 to 500 microns in length and 10 to 40 microns in width). Thus, even though they may occur in finished tap water, they are unnoticed by the consumer because of their minute size. Occurrence in finished water does, however, indicate that modern water treatment methods are not always fully successful as barriers to invasion by microorganisms. The public health significance of microorganisms in drinking water has been pointed out by Chang and co-workers.* Supplies that reveal worms on microscopic examination should be scrutinized by the operator or others in authority to make certain that a public health hazard does not exist and that measures of disinfection are put into practice that will effectively destroy roundworms.

MOLLUSKS

To date, published literature on mollusk nuisances in distribution systems in the United States refers to only one snail, Bythinia tentaculata (Plate III, Fig. 2), originally introduced from Europe (Abbott, 1950). Other snail genera have been found as occasional residents of finished water in clear wells but have not caused difficulty in distribution systems (Ingram and Bartsch, 1960, 1960a). Clam

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* Op. cit., this paper page 3.

nuisances have not yet been reported to be in distribution systems in the United States; however, one species, Corbicula fluminea (Plate III, Fig. 3), introduced from Asia and bordering Pacific Islands, has been recorded as causing trouble in raw drinking water supplies and in the canal transportation system of the LaVerne water softening plant of the Metropolitan Water District of Southern California (Ingram, 1956, 1959). This clam has a life cycle that, in prognostication, should eventually cause it to be listed as a nuisance in treated supplies. It is established as a pest in pipes of irrigation systems in California (Ingram, 1959). Since the time of the first published record of its distribution in the United States as an inhabitant of certain streams in California and Washington (Ingram, 1948), it has spread to waterways in Arizona, Oregon, Idaho, Tennessee, and Ohio (Ingram, 1959, Sinclair and Ingram, 1961, Dundee and Dundee, 1958).

The snail, Bythinia tentaculata, as the mollusk invader of bathtubs and kitchen sinks, has been named the faucet snail. Baker (1902) while studying drinking water from Lake Michigan first collected this snail in the United States in 1898 as an intermittent household guest. The snails were pumped into the distribution system of the Chicago area, which was supplied by the Lake View Crib intake. During this infestation it was found occluding small water pipes in residences; in a number of instances tumblerfuls of snails issued from faucets. Two other snails associated with this snail in the crib structure were not reported from faucets (Pleurocera elevatum and Goniobasis livescens). Remedial measures are not described.

Sterki (1911) records an infestation of the Erie, Pennsylvania, water system when the raw source was Lake Erie. The intake at the time was four to five miles out in the lake. He noted that "...wagon-loads..." of snails were taken from the crib structure when it was cleaned and that snails often plugged faucets. Two genera of snails that were collected with Bythinia but not reported to cause nuisances were Physa and Helisoma (=Planorbis). Bahlman (1931, 1932) found empty shells of Planorbis (=Helisoma) in the clear well of the Cincinnati, Ohio, filtration plant but did not report snail nuisances in the distribution system drawing from the clear well.

MIDGEFLY LARVAE

In the water treatment profession the well known "bloodworm" is the immature, larval stage of a midgefly (Plate IV, Fig. 1). Taxonomically it is placed in the genus Tendipes (=Chironomus is the common generic term used by professional water supply journals). In most instances, the worm-like larvae that have been reported in distribution systems have been ones with blood-red coloring, although the larvae of various species may range from red, through yellow, brown, or green. Invariably, bloodworms enter into distribution systems from uncovered, finished-water reservoirs or from covered reservoirs with broken screens over side vents.

Adult midges lay their eggs in jelly-like strings, enveloped by a gelatinous covering. The eggs are free floating on the water surface

or attached to aquatic plants, twigs, or stones. One species, Tendipes (=Chironomus) plumosus, has been associated with finished water supplies, as well as with streams polluted by domestic sewage. Populations of 250 larvae per square foot have been recorded in eutrophic lakes (Townes, 1938).

Bahlman's (1931, 1932) papers are among the early ones that report bloodworms from finished water that had been thoroughly treated in a filtration plant. He first discovered these organisms in the uncovered clear well on the grounds of the Cincinnati plant and concluded that they multiplied by feeding on algal growths and decaying leaves that had accumulated, forming a bottom sludge. He noted that "...a complete covering of the clear-well reservoir is the only means of maintaining an aesthetic supply." Bloodworms were eventually reported emerging from bathtub faucets and in toilet bowls in a suburban family hotel.

Hechmer (1932) reported that Chironomus plumosus was found in finished-water tanks in the filtration plant of the Washington, D. C.-Maryland Suburban Sanitary District. He states that they did not pass through the sand filters, but developed in the finished water from eggs that were deposited directly on the finished-water tanks. Larvae discharged from faucets caused consumer complaints. The bloodworm problem was eliminated for the householder by covering the filtered-, finished-water tanks.

Flentje (1945) reported on the elimination of colorless to pale-green bloodworms, four to five millimeters long, from the

distribution system at Alexandria, Virginia. The foci of the infestation were two finished-water reservoirs. Flentje (1945a) recorded his over-all experiences with bloodworms from many years in the waterworks field, and summated the literature.

Brown (1933) discussed a bloodworm infestation of a distribution system and found the point of development to be a reservoir of the Stockton, California, potable supply. The reservoir had a collapsed roof.

CRUSTACEA

Crustacea represented by water fleas (Daphnia and Bosmina) and cyclops (Cyclops) have long been of interest to water treatment plant operators since they have been reported from various basins in the filtration plant. They are frequently observed in unfiltered supplies.

Water fleas in finished water in distribution systems have been reported by Hart (1957). Kelly (1955) reported Daphnia in finished water in the effluents of slow sand filters. Hobbs (1950) states that slight difficulty has been encountered from penetration of filters by Daphnia. Cox (1946) indicates that they are removed from potable supplies by filtration.

Adult cyclops were prevented from entering finished water by sand filters at Indianapolis, Indiana (Crabill, 1956); however, the eggs did go through filters and hatched in the finished water, which resulted in adults being carried to the consumer. As many as twenty eggs per liter were

counted from finished water on the effluent side of the filters at the height of this infestation. Hart (1957) implies that the cyclops eggs, rather than the adults, pass through filters, thus accounting for the appearance of mature forms in potable supplies. Baylis (1957) reported that cyclops were taken from filter surfaces of Chicago's South District Filtration Plant. No mention was made of their occurrence in finished water.

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PLATE IV: Fig. 1, Bloodworms: Chironomus: The left diagram shows the pupa (3.9x); the right, the larva (2.8x). Fig. 2, Cyclops: Cyclops: The two oval extensions from the body contain eggs (30x). Fig. 3, Water Flea: Daphnia (35x).

PLATE III: Fig. 1, Roundworms: Male and female nematodes (100x). Fig. 2, Faucet Snail: Bythinia (4.5x). Fig. 3, Asiatic Clam: Corbicula (1.5x).

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